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DYNAMIC DROP AND VIBRATION TESTS OF A CNU-104/E SHIPPING CONTAINER

Dave Bogan
Nash-Hammond, Inc.

TECHNICAL REPORT AFATL-TR-68-12

JANUARY 1968

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DYNAMIC DROP AND VIBRATION TESTS OF A CNU-104/E SHIPPING CONTAINER

Dave Bogan

FOREWORD

This program was authorized by U. S. Air Force Contract No. F08635-67-C-0049 during the period 19 December 1966 to 9 May 1967. The program monitor for the project was Captain R. Bennett (ATWD), Air Force Armament Laboratory, Eglin Air Force Base, Florida, in conjunction with Dr. Harry Freeman, Picatinny Arsenal, Dover, New Jersey.

Nash-Hammond, Inc., Industry, California, was responsible for the manufacture and tests of the Shipping Container.

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This technical report has been reviewed and is approved.

C. K. ARPKE, Lt. Colonel, USAF
Acting Chief, Weapons Division

ABSTRACT

This report presents the results of two dynamics: Rough Handling and Vibration tests of a CNU-104/E Shipping Container. The container was designed to protect the fully loaded TFDM dispenser and pallet from damage during shipment. The purpose of the tests was to ascertain the practicability of a rotationally molded high density linear polyethylene shipping container to provide protection during shipment and long-term storage. Two test specimens, No. 1 and No. 2 for vibration testing, and one test specimen for rough handling testing, were subjected to all tests with successful results. The procedures and results presented within this report include those performed outside the facilities of Nash-Hammond industry.

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SECTION I

INTRODUCTION

1. GENERAL

The feasibility of using a plastic material in the form of a shipping container having a load of 840 lb exceeding 1 lb psi, heretofore, was deemed impractical. With the process known as "Rotation Molding" together with the development of "High Density Linear Polyethylene" for this process, a double wall container which is able to sustain such loads was deemed possible and, indeed, practical. The double wall container design has a built-in shock absorbing agent in that the inner wall cradles the item (TFDM Dispenser) enabling it to move with the shock. No additional internal cushioning is necessary if the TFDM Dispenser is fairly rugged and is able to function after a 30g shock.

Rotational molding has an inherent quality peculiar only to the process in that angles and radii have a built-up thickness as compared to a flat side. This automatically puts the strength where it is most needed in container application. This container, hereafter referred to as the CNU-104/E, was developed for the U. S. Air Force by Nash-Hammond, Inc., City of Industry, California, under Contract No. F08635-67-C-0049.

2. TEST OBJECTIVE

The objective of this test program was to evaluate the CNU-104/E Shipping Container under dynamic test conditions which are as follows:

Test Number	Description
	Rough Handling
1	Forward End Pendulum
2	Aft End Pendulum
3	Aft Right Corner Drop
4	Forward Left Corner Drop
5	Forward End Drop
6	Aft End Drop
	Environmental and Vibration
7	Pressure (unloaded)
8	High Temperature (unloaded)
9	Low Temperature (unloaded)
10	Vibration (loaded)

SECTION II

TEST PACKAGE

1. GENERAL

An exploded schematic view of the CNU-104/E Shipping Container is shown in Figure 1. The components of the Container are indicated on the drawing. The approximate dimensions of the assembled Container were 24-1/2 inches in width, 29-1/8 inches in height, and 153-1/4 inches in length. The gross weight of the unloaded Container was approximately 189 pounds including the foam fill.

2. WEAPON CYLINDER

The weapon cylinder consisted of a functioning TFDM, dummy loaded stainless steel cylinder. The weapon was furnished by the Air Force. Figure 1 shows the weapon installed in the lower half of the Shipping Container.

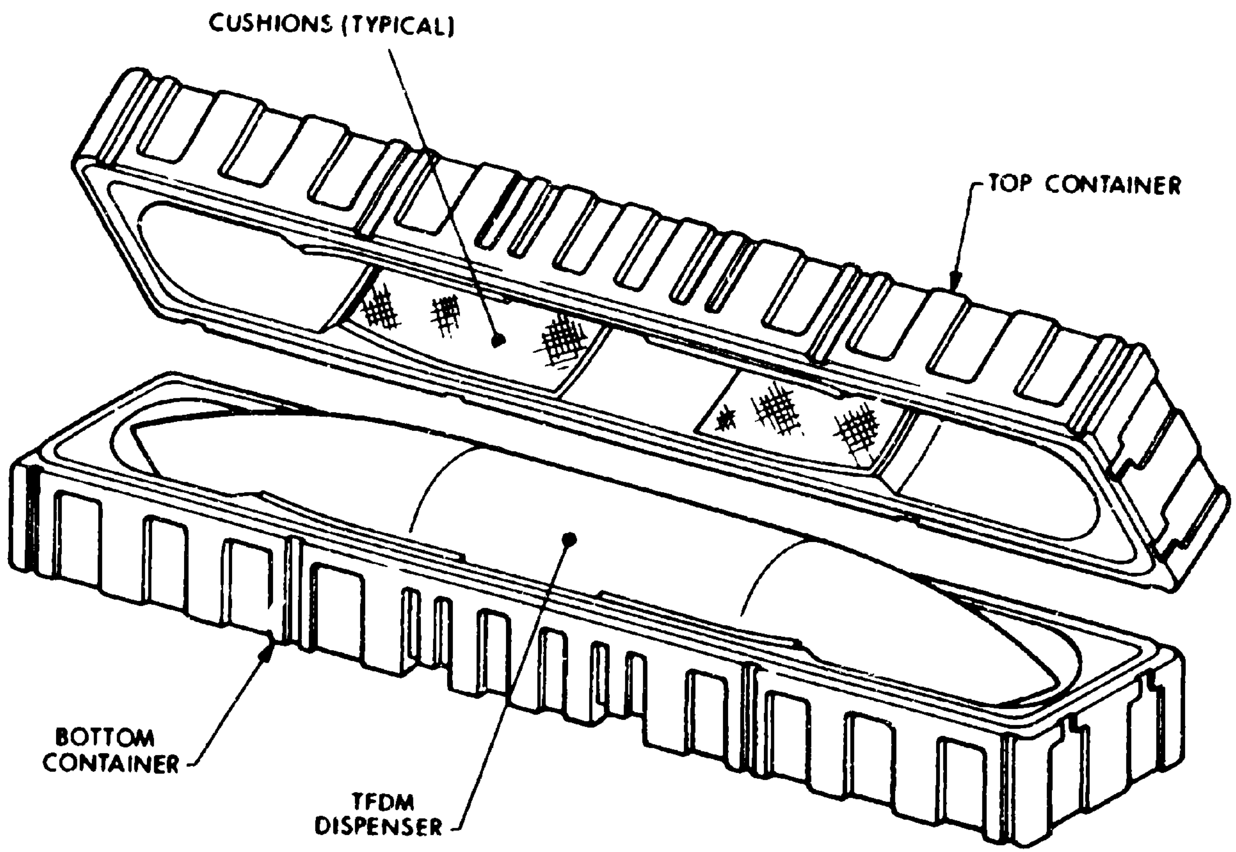

Figure 1. Exploded Schematic View of the CNU-104/E Shipping Container

SECTION III

TEST PROCEDURE

1. INSTRUMENTATION SYSTEM

a. Rough Handling Tests

Five accelerometers were used to measure the vertical and lateral accelerations at each end of the TFDM Dispenser and the longitudinal acceleration at the centerline. The accelerometers were connected to CEC System D galvanometer carrier amplifiers consisting of one power supply and master oscillator type 2-105A, and eight channels of type 1-113B carrier amplifiers. The galvanometer carrier amplifiers were connected to a CEC type 5-116 P4-14 recording oscillograph equipped with eight type 7-323 fluid damped galvanometers.

The accelerometers were bonded to the Shipping Container with pressure sensitive adhesive tape. Access for the electrical cables was provided by a 1/2-inch diameter hole in one forward side of the Container. Figure 2 shows the location of the accelerometers.

b. Vibration Tests

The Shipping Container and its contents were vibrated in three major mutually perpendicular axes on an MB Electronics Vibration Exciter, which utilized a type T-68 vibration control console. Six piezoelectric type accelerometers were used. One accelerometer was used for vibration input control on the test fixture, and the remaining five accelerometers were used to monitor the response of the TFDM Dispenser located internally within the Shipping Container under test. Figure 3 illustrates the location of the accelerometers for each axis of vibration testing.

During the resonant survey test for each axis, the accelerometer output was recorded on a direct writing Bristol Temperature Recorder, Model M/N 20PG560-21. For a complete description of test equipment used in the execution of the tests indicated, and for pressure, high temperature, and low temperature tests, see the appendix section of this document.

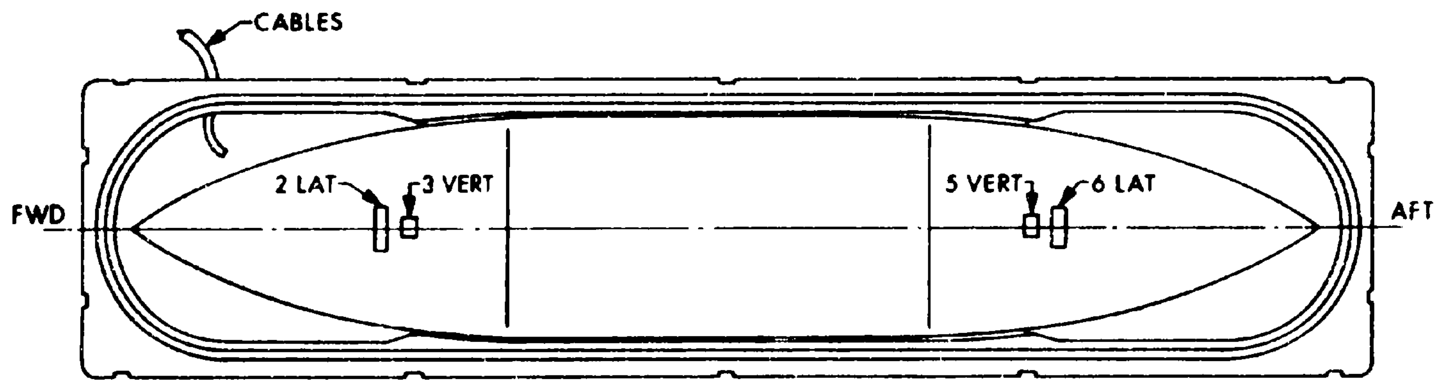

Figure 2. Location of Accelerometers, Rough Handling Test

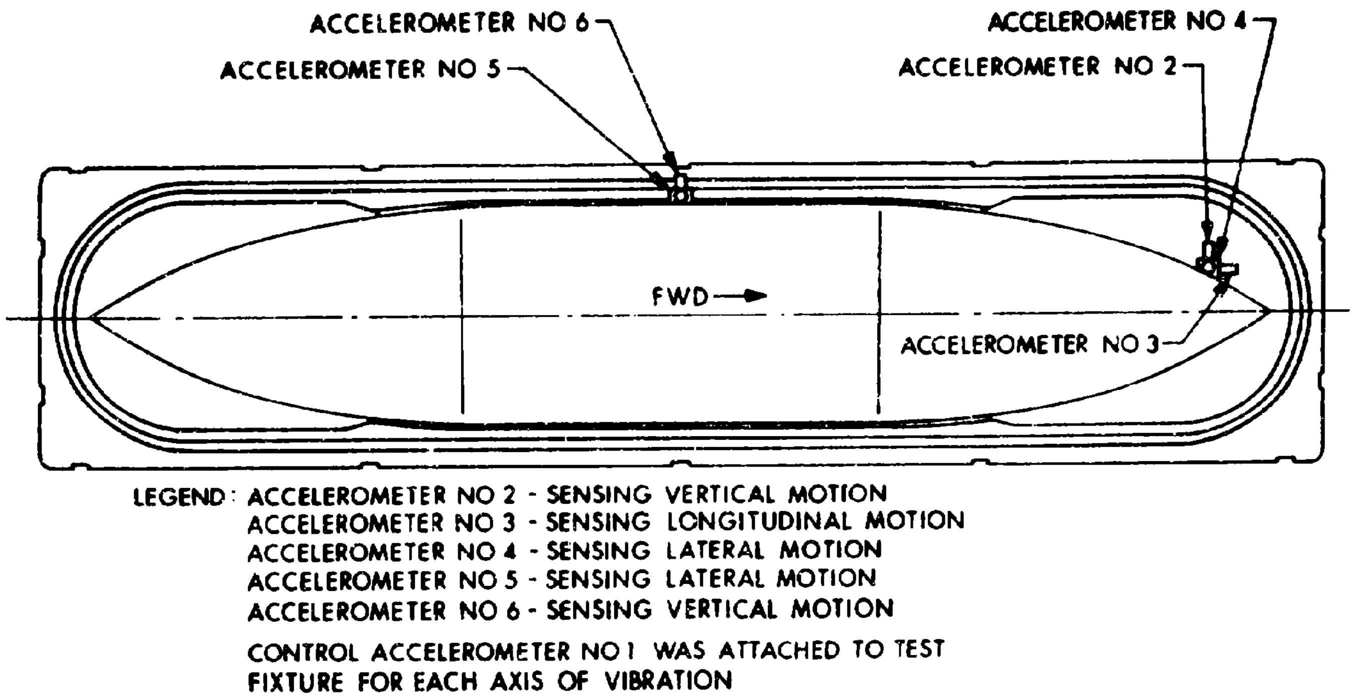

Figure 3. Location of Accelerometers, Vibration Test

SECTION IV

TEST RESULTS

1. GENERAL

a. Description of Rough Handling Tests

The rough handling tests performed on the loaded Container were conducted in accordance with Military Standard MIL-STD-810, Method 516 (Procedure III), at ambient temperature and are described in Section I, paragraph 2. Channel 6 (aft lateral accelerometer) did not function during the tests. This condition was discovered after the first drop, but since the Container was banded closed and the level of the lateral accelerations was minimal, it was decided to proceed with the tests without this channel. The rough handling test results are described in Table I. The values are given in terms of g units (1g = 32.2 ft/sec^2) and since these are peak values they do not necessarily happen at the same instant of time.

b. Description of Environmental and Vibration Tests

The environmental tests performed on the loaded Container were conducted in accordance with Military Standard MIL-STD-810, Methods 500, 502, 501, and 514, at ambient temperature, under standard laboratory conditions, and are described in Section I, paragraph 2.

TABLE I. SUMMARY OF PEAK ACCELERATION

Record No.	Height (inches)	Description	2 FL	3 FV	4 L	5 AV
2500	9	Forward End Pendulum	0.9	2.2	3.4	2.3
2501	9	Aft End Pendulum	0.4	2.6	3.3	3.0
2502	24	Aft Right Corner	3.0	6.5	1.6	10.2
2503	24	Forward Left Corner	4.9	10.2	2.0	6.4
2504	24	Forward End Drop	1.0	24.3	4.1	10.4
2505	24	Aft End Drop	1.8	10.4	4.1	24.6

Reference should be made to Figures 7 through 12 in the Appendix for time correlation.

2, ROUGH HANDLING TESTS

a. Pendulum Input Tests (refer to Table I for "g" values)

(1) Dispenser Movement, Forward End

The Dispenser (without cones) was located in the Shipping Container 33 inches from aft end to outside Container wall. During impact, the dispenser moved forward 1.50 inches to 34.50 inches. A visual inspection of the Shipping Container and dispenser revealed no evidence of damage.

(2) Pendulum, Forward End

The loaded Shipping Container was raised 17.50 inches off a concrete slab and continued to be raised on an arc until C.G. was 26.50 inches. The Shipping Container was then released, butting into a 6-inch concrete wall. A visual inspection of the Shipping Container and dispenser revealed no evidence of damage.

(3) Dispenser Movement, Aft End

Dispenser (without cones) was located 34.5 inches from aft end of dispenser to outside of Container end wall. During impact, dispenser moved forward 3.0 inches to 31.50 inches. Inside clearance of dispenser, with cones, to inside wall of Container is 6.0 inches at both forward and aft ends.

(4) Pendulum, Aft End

The loaded Shipping Container was raised until C.G. was at 19.5 inches off a concrete slab, then continued to be raised on an arc until C.G. was 28.50 inches. Container was then released, butting into a 6-inch concrete wall. A visual inspection of the Shipping Container and dispenser revealed no evidence of damage.

b. Corner Drop Tests

(1) Forward End

One 5-inch block and one 12-inch block were placed under the forward corners of the loaded Container. The aft end was then raised to a height of 24 inches and released for a free fall drop to the concrete floor. A visual inspection of the Shipping Container and dispenser revealed no evidence of damage.

(2) Aft End

One 5-inch block and one 12-inch block were placed under forward corners of the loaded Shipping Container. The aft end was then raised to a height of 24 inches and released for a free fall drop to the concrete floor. A visual inspection of the Shipping Container and dispenser revealed no evidence of damage.

c. Edgewise Drop Tests

(1) Forward End

One 6-inch block, 12 inches long, was centered under the aft end of the Shipping Container. The forward end was raised to a height of 24 inches and then released for a free fall drop onto a concrete floor. A visual inspection of the Container revealed that structural damage had occurred. The aft end buckled at a point centered in the bottom end, protruding approximately 1.50 inches. This condition was caused by the corners of the aft end not being supported by the 12-inch long block. However, no evidence of damage to the dispenser was revealed.

(2) Aft End

One 6-inch block, 24 inches long, was centered under the forward end of the Shipping Container. The aft end was then raised to a height of 24 inches and released for a free fall drop onto a concrete floor. A visual inspection of the Container and dispenser revealed no evidence of damage.

3. ENVIRONMENTAL AND VIBRATION TESTS

a. Pressure Test

The unloaded Shipping Container (test specimen No. 1) was placed within a suitable altitude test chamber. Pressure within the test chamber was reduced to 3.44 Hg (50,000 feet above sea level) and was maintained at this pressure for a period of one hour. Internal chamber temperature during the test period was uncontrolled.

At the conclusion of the one-hour period, the test chamber was returned to atmospheric conditions. The test specimen was examined for evidence of structural or mechanical damage. The Shipping Container inspection revealed no evidence of damage.

b. High Temperature Test

The unloaded Shipping Container (test specimen No. 1) was placed within a suitable high-temperature test chamber. Temperature within the test chamber was increased to 160°F (71.1°C) and maintained at this temperature for a period of 48 hours. At the conclusion of the 48-hour period, the test chamber was returned to laboratory ambient test conditions. The test specimen was examined externally for evidence of structural or mechanical damage and deterioration. The Shipping Container inspection revealed no evidence of damage.

c. Low Temperature Test

The unloaded Shipping Container (test specimen No. 1) was placed in a suitable low-temperature test chamber. The test chamber's internal temperature was lowered to -80°F (62.2°C) and was held at this temperature for a period of 48 hours. At the conclusion of the 48-hour period, the door to the test chamber was opened and the test specimen was allowed to return to laboratory ambient test conditions.

After stabilization, at laboratory ambient test conditions, the test specimen was examined externally for any evidence of damage or deterioration. The Shipping Container inspection revealed no evidence of damage.

d. Vibration Test

The Shipping Container and its contents (test sample No. 2) were rigidly attached to the vibration exciter (Figure 4) and were vibrated in accordance with requirements of MIL-STD-810, at ambient temperature. During the resonant dwell test in each axis, "short bursts" of the accelerometers were recorded at five-minute intervals during testing between 2 to 26 Hz and at the beginning and end of each resonant dwell between 26 to 300 Hz. Vibration testing was conducted as follows:

(1) Resonant Search

While rigidly attached to the vibration exciter, the test sample was subjected to a resonant search test in each of the test samples three major mutually perpendicular axes as set forth in Figures 4, 5, and 6. The resonant search test was conducted at the frequencies and vibration inputs set forth in Table II.

TABLE II. FREQUENCY AND VIBRATION TEST SCHEDULE

Frequency (Hz)	Vibration Input
2 to 10 to 2	0.13" DA
10 to 17 to 10	0.09" DA
17 to 20 to 17	1.3 g
26 to 52 to 26	0.036" DA
52 to 300 to 52	5.0 g

During performance of the resonant search test, the oscillograph recorder was continuously operated to determine test sample response.

(2) Vibration Cycling Test

At the conclusion of the resonant search test in each axis, the test sample was subjected to vibrations cycling at the frequencies, vibration amplitudes, and time durations as set forth in Table III.

At the conclusion of each frequency range, the test sample was externally examined for evidence of damage or deterioration. The Shipping Container inspection revealed no evidence of damage.

Figure 4. Vibration Test, Vertical Axis

Figure 5. Vibration Test, Lateral Axis

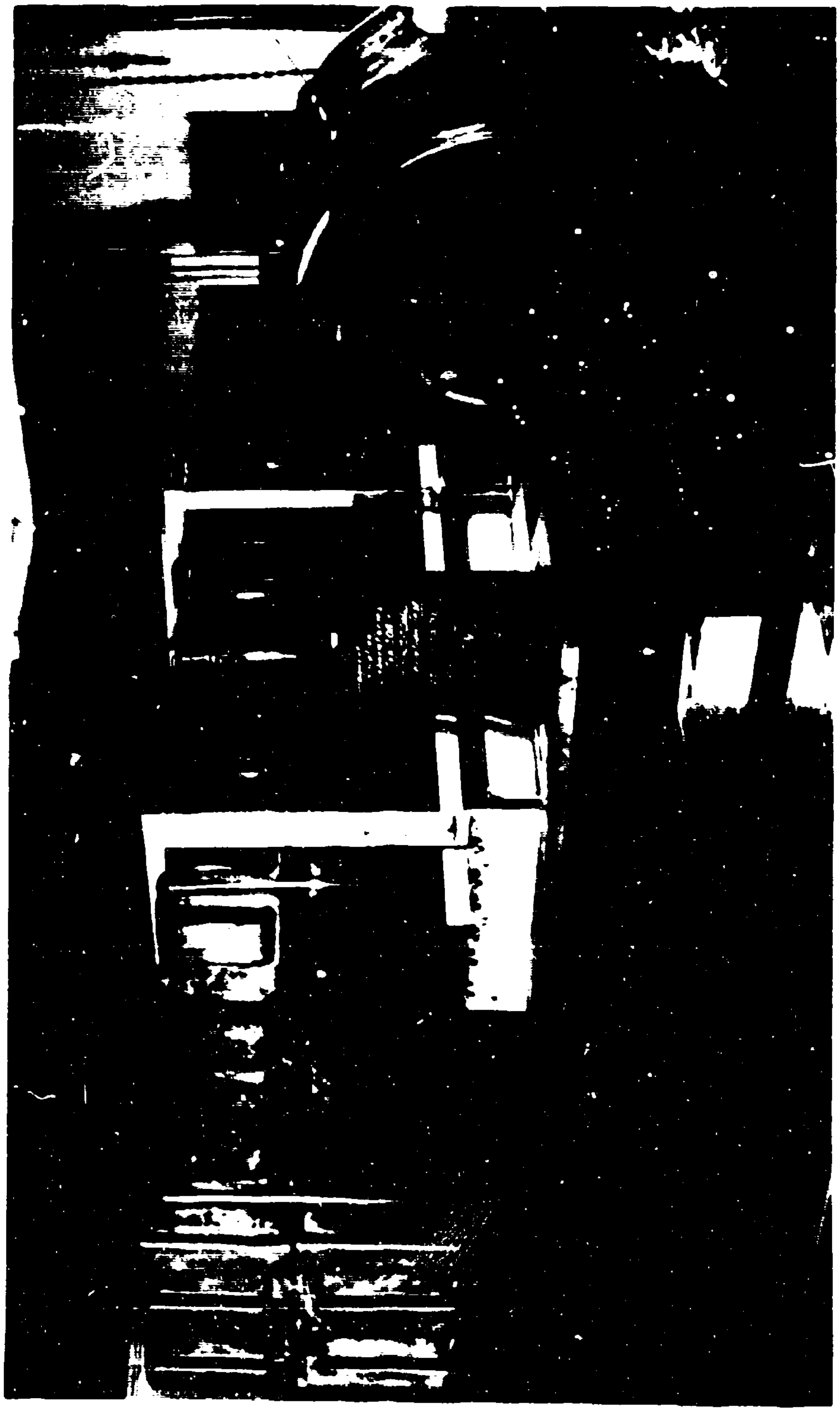

Figure 6. Vibration Test, Longitudinal Axis

TABLE III. FREQUENCIES, VIBRATION AMPLITUDES, AND TIME DURATIONS

Frequency Range (Hz)	Cycling Time Duration (minutes)	Vibration Input
2 to 6 to 2	10	0.5 g*
6 to 9 to 6	10	0.3" DA
9 to 26 to 9	30	1.3 g
26 to 52 to 26	20	0.036" DA
52 to 300 to 52	50	5.0 g

*Vibration input was limited to 1" DA or 0.5g, whichever was the limiting factor.

(3) Resonant Dwell Test

At the conclusion of the vibration cycling test in each axis, the test sample was subjected to a resonant dwell test at the most severe resonant frequency in each frequency range set forth in Table II. The resonant dwell test was conducted at the resonant frequencies, vibration input levels, and time durations set forth in Table IV.

At the conclusion of each resonant frequency dwell noted in Table III, the test sample was externally examined for evidence of damage or deterioration. The Shipping Container inspection revealed no evidence of damage.

TABLE IV. RESONANT DWELL TEST SCHEDULE

Resonant Frequency (Hz)	Axis	Vibration Input	Dwell Time (minutes)	Accelerometer Response (g) Accel. No.				
				2	3	4	5	6
10	Vertical	0.13" DA	70	0.6	0	0.2	0.6	0
17	Vertical	0.09" DA	70	0.8	0	0	0.7	0
50	Vertical	0.036" DA	60	3	1	2	2	1.2
93	Vertical	5.0 g	30	1.2	1.1	2	2	1.2
195	Vertical	5.0 g	30	1.2	0.5	2	3.3	0.8
10	Lateral	0.13" DA	3	3	0.9	2.8	1.6	1.8
17	Lateral	0.09" DA	3	3	1.0	3	2	2.5
24	Lateral	1.3 g	3	3	1.0	3.5	2.5	2.5
51	Lateral	0.036" DA	7	7	2	7	7	5
90	Lateral	5.0 g	4	4	1	8	6	4
10	Longitudinal	0.13" DA	2	2	1	4	1	1
22	Longitudinal	1.3 g	1.3	1.3	1	1.8	0.5	0.4
52	Longitudinal	5.0 g	3	3	2	2	1	1
170	Longitudinal	5.0 g	3	3	1	5	1	[illegible]
290	Longitudinal	5.0 g	3	3	0.5	5	2	0.8

SECTION V

EVALUATION

The Shipping Container demonstrated satisfactory achievement of the design objectives, without exception, although the only visual damage to the container occurred during the Edgewise Drop Test, Forward End. The insignificant buckling that occurred, visual at the time of impact, returned to normal twelve (12) hours after test, leaving a slight stress line and with no visual damage to the dispenser at any time during the tests.

SECTION VI

CONCLUSIONS

The Shipping Container suffered only superficial damage as a result of the tests described in the proceeding paragraphs. The test results indicate no subsequent malfunction nor affected reusability of the Container. There was no evident damage to the TFDM Dispenser after the rough-handling and vibration tests. On the basis of these findings, it is reasonable to conclude that rotationally molded, high density polyethylene, double wall Shipping Containers will adequately protect the dispenser from such shock and vibration as might be encountered during shipment and storage.

The dimensional limitations of containers manufactured by this process have not been determined; however, it is the consensus of opinion that a 24-foot length Container would be approaching the limit. The state of the art is rapidly improving not only in the physical properties of the basic material and manufacturing methods, but also in the economics involved.

SECTION VII

RECOMMENDATIONS

It is recommended that:

1. The bottom of the Container be partially foam filled between the fork lift areas to facilitate closing, due to slight warpage of the closure when loaded. The warpage occurs approximately one hour after the lid has been removed. If the contents have not been removed from the Shipping Container after one hour, warpage will result and replacement of the lid on Shipping Container becomes difficult. Foam fill will correct this situation. If contents are removed, however, any warpage will correct itself due to the memory characteristics of the plastic material.

2. The black color be used because of its resistance to ultraviolet rays. This material has been known to have an outside storage life expectancy exceeding twenty years.

3. The method of closure used be nylon strapping, as this is deemed much more practical than latch-type closures in three respects: a) quicker access to the contents; b) no maintenance required; and c) the additional cost of latches is not justified.

APPENDIX

DESCRIPTION OF TEST EQUIPMENT

Nomenclature	Characteristics
Vibration Exciter	
MB Electronics M/N C-21- CEL No. 2-156	Range: 5 to 2000 Hz 28,000 Force lb/sine 25,000 Force lb/random Accuracy: Waveform distortion - ±15% fs output Calib. Interval: 6 months
Vibration Control Console	
MB Electronics M/N T-68 CEL No. 2-162	Range: 5 to 10,000 Hz Accuracy: ±5.0% rdg. Calib. Interval: 1 month
Vibration Power Supply	
MB Electronics M/N 999 S/N 105 CEL No. 2-161	Range: 5 to 5000 Hz 78 kW output Accuracy: Externally instrumented Calib. Interval: NA
Temperature, Humidity Chamber	
10' x 20' x 20' CEL M/N H-LT-H1900 S/N 1 CEL No. 2-171	Range: $-80^{\circ}F$ to $+200^{\circ}F$; 95% RH Accuracy: $\pm 3.6^{\circ}F$; ±5.0% RH Calib. Interval: Prior to use
Electronic EPUT Counter	
Systron Donner M/N 1032 S/N 205 CEL No. 1-191	Range: Frequency - 0 Hz to 1.0 mc Period - 1 microsec to 10 sec Accuracy: ±0.1 ppm/day; ± 1 digit Calib. Interval: 12 months
Millivolt Indicator	
Minneapolis-Honeywell M/N 126W3V-11-111-IV-TZ S/N 942671 CEL No. 3-554	Range: 0 to 71 mV; 2 channels Accuracy: ±0.05% mV Calib. Interval: 6 months
Temperature Recorder	
Bristol Co. M/N 20PG560-21 S/N 645119 CEL No. 3-570-2	Range: $-100^{\circ}F$ to $+500^{\circ}F$ 1 channel; CC thermocouple Accuracy: ±0.5% fs Calib. Interval: 3 months

APPENDIX (cont)

Nomenclature	Characteristics
Power Supply Unholtz-Dickie Corp. M/N 608PS-1 S/N 126 CEL No. 3-684	Range: NA Accuracy: NA Calib. Interval: NA
Auto Ranger Modules (2) Unholtz-Dickie Corp. M/N 8PMCVA CEL No. 3-684-1 CEL No. 3-684-2	Range: Charge Mode - Sensitivity - 1 to 100 pcmb (peak)/g (peak) Frequency response - 10 Hz to 10 kHz = ±1% 5 Hz to 10 kHz = ±2% 3 Hz to 10 kHz = ±4% Voltage Mode - 1 to 100 mV (peak)/g (peak) Accuracy: Gain - ±1.5% at any point on the dial Meter - ±1% fs Calib. Interval: Prior to use
Power Supply Unholtz-Dickie Corp. M/N 608PS-1 S/N 112 CEL No. 3-685	Range: NA Accuracy: NA Calib. Interval: NA
Auto Ranger Modules (2) Unholtz-Dickie Corp. M/N 8PMCVA CEL No. 3-685-1 CEL No. 3-685-2	Range: Charge Mode - Sensitivity - 1 to 100 pcmb (peak)/g (peak) Frequency response - 10 Hz to 10 kHz = ±1% 5 Hz to 10 kHz = ±2% 3 Hz to 10 kHz = ±4% Voltage Mode - 1 to 100 mV (peak)/g (peak) Accuracy: Gain - ±1.5% at any point on the dial Meter - ±1% fs Calib. Interval: Prior to use
Power Supply Unholtz-Dickie Corp. M/N 608PS-1 S/N 118 CEL No. 3-686	Range: NA Accuracy: NA Calib. Interval: NA

APPENDIX (cont)

Nomenclature	Characteristics
Auto Ranger Modules (2) Unholtz-Dickie Corp. M/N 8PMCVA CEL No. 3-686-1 CEL No. 3-686-2	Range: Charge Mode - Sensitivity - 1 to 100 pcmb (peak)/g (peak) Frequency response - 10 Hz to 10 kHz = ±1% 5 Hz to 10 kHz = ±2% 3 Hz to 10 kHz = ±4% Voltage Mode - 1 to 100 mV (peak)/g (peak) Accuracy: Gain - ±1.5% at any point on the dial Meter - ±1% fs Calib. Interval: Prior to use
Piezoelectric Accelerometer Endevco M/N 2213C S/N KA 91 CEL No. 3-447-1	Range: 5 to 4000 Hz 0 to 10,000 g Frequency response - ±2.5% to 4000 Hz nominal Sensitivity - 35.3 rms mV/g peak Transverse sensitivity - 2.2% Accuracy: Linearity - ±1.0% fs Calib. Interval: 6 months
Piezoelectric Accelerometer MB Electronics M/N 304 S/N 163201 CEL No. 3-449-9	Range: 0.15 to 10,000 g Sensitivity - 54.5 rms mV/g peak Frequency response - 2 Hz to 7 kc Accuracy: Linearity - ±1.0% fs Calib. Interval: 1 month
Piezoelectric Accelerometer MB Electronics M/N 305 S/N 182036 CEL No. 3-449-17	Range: 0.15 to 10,000 g Sensitivity - 16.8 rms mV/g peak Frequency response - 2 Hz to 7 kc Accuracy: Linearity - ±1.0% fs Calib. Interval: Prior to use
Piezoelectric Accelerometer MB Electronics M/N 305 S/N 182032 CEL No. 3-449-18	Range: 0.15 to 10,000 g Sensitivity - 17.2 rms mV/g peak Frequency response - 2 Hz to 7 kc Accuracy: Linearity - ±1% fs Calib. Interval: Prior to use

APPENDIX (concluded)

Nomenclature	Characteristics
Piezoelectric Accelerometer	
MB Electronics M/N 305 S/N 163360 CEL No. 3-449-19	Range: 0.15 to 10,000 g Sensitivity - 18.0 rms mV/g peak Frequency response - 2 Hz to 7 kc Accuracy: Linearity - ±1% fs Calib. Interval: Prior to use
Piezoelectric Accelerometer	
MB Electronics M/N 305 S/N 163269 CEL No. 3-449-20	Range: 0.15 to 10,000 g Sensitivity - 17.3 rms mV/g peak Frequency response - 2 Hz to 7kc Accuracy: Linearity - ±1.0% fs Calib. Interval: Prior to use
Piezoelectric Accelerometer	
MB Electronics M/N 305 S/N 163294 CEL No. 3-449-21	Range: 0.15 to 10,000 g Sensitivity - 17.6 rms mV/g peak Frequency response - 2 Hz to 7 kc Charge - 17.9 pC/g Accuracy: Linearity - ±1.0% fs Calib. Interval: Prior to use
Stop Watch	
Braun CEL No. 4-643	Range: 1 sec to 30 min Accuracy: ±0.5 sec Calib. Interval: 6 months

All equipment utilized was currently in calibration as outlined in Component Evaluation Laboratories Quality Control Manual.

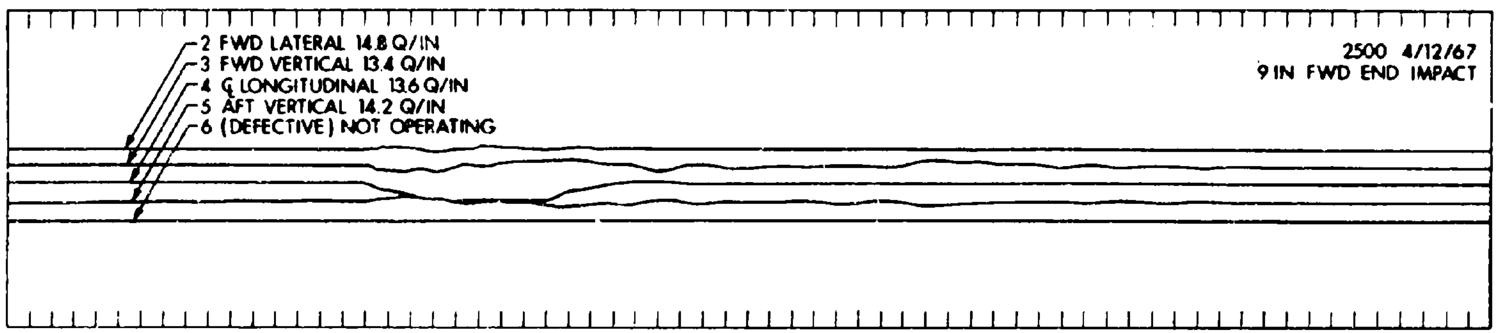

Figure 7. Rough Handling Test, 9" Forward End Impact

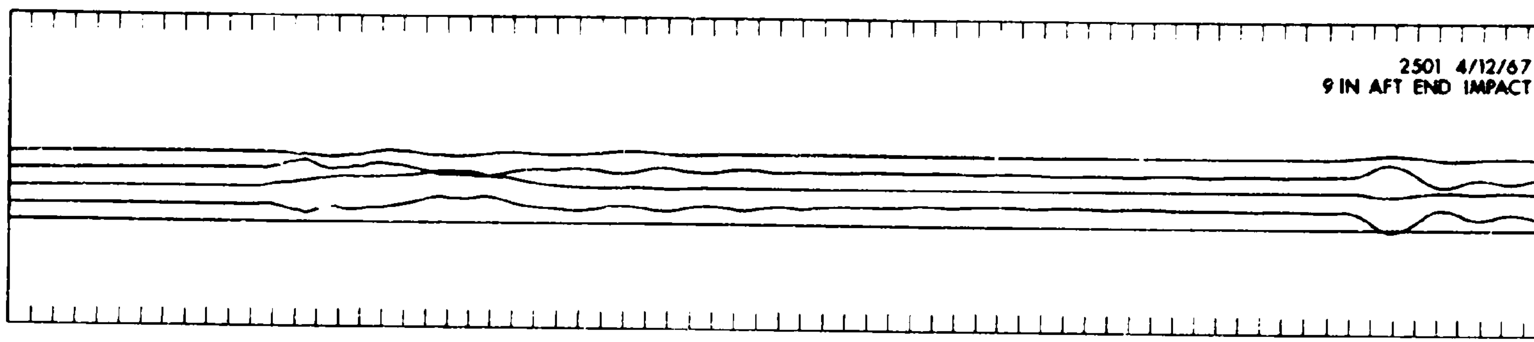

Figure 8. Rough Handling Test, 9" Aft End Impact

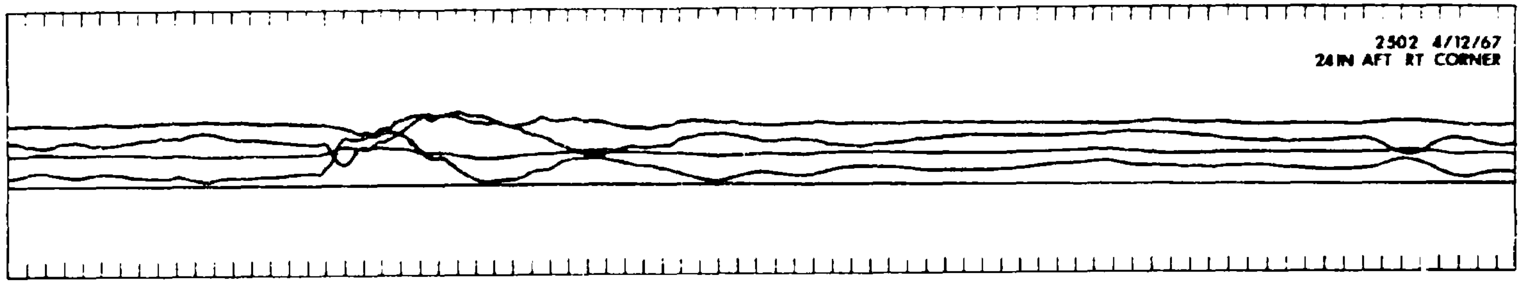

Figure 9. Rough Handling Test, 24" Aft Right Corner

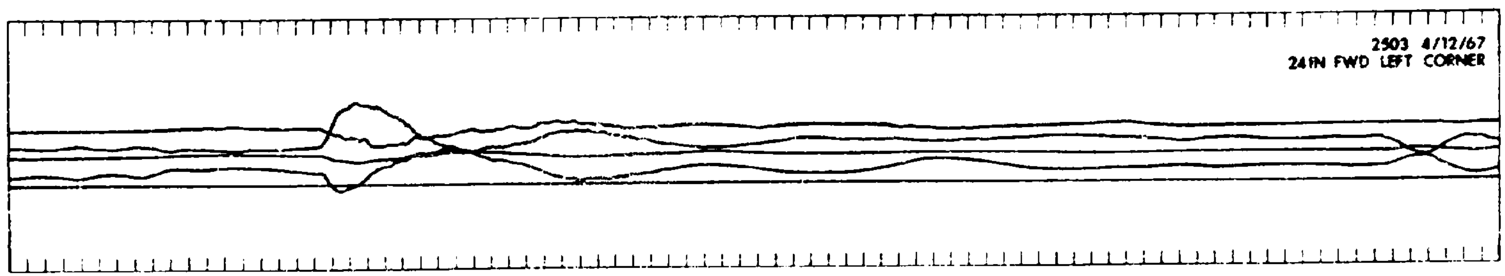

Figure 10. Rough Handling Test, 24" Forward Left Corner

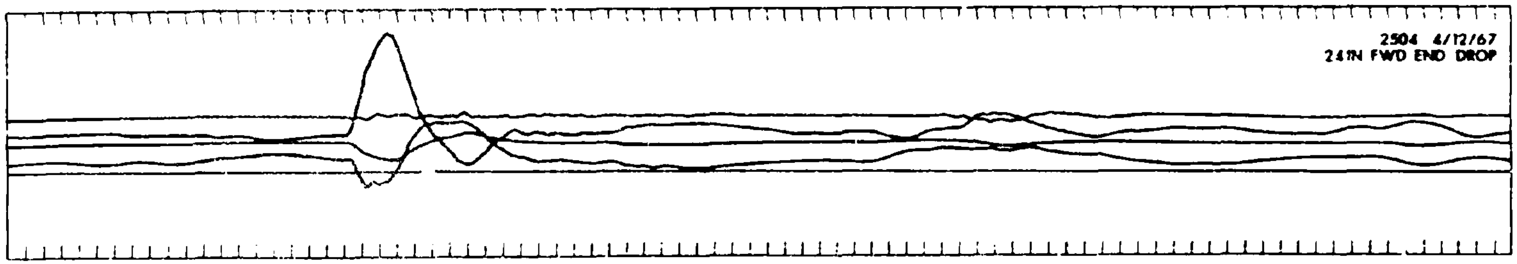

Figure 11. Rough Handling Test, 24" Forward End Drop

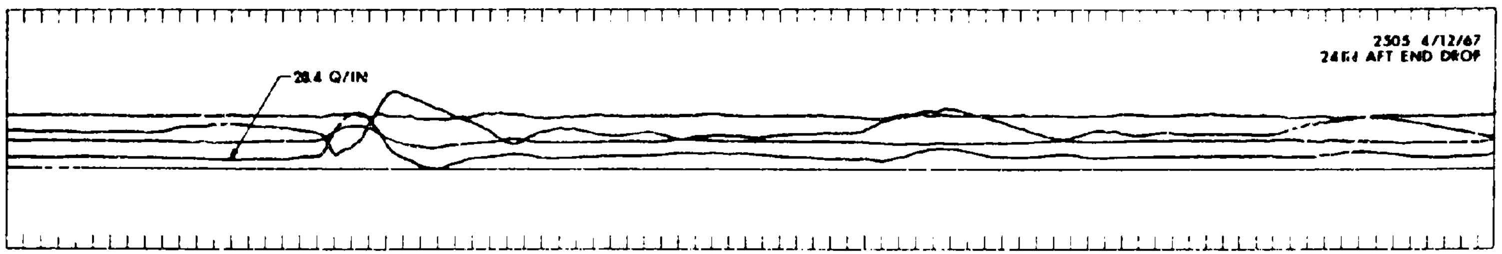

Figure 12. Rough Handling Test, 24" Aft End Drop

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13. ABSTRACT

This report presents the results of two dynamics: Rough Handling and Vibration tests of a CNU-104/E Shipping Container. The container was designed to protect the fully loaded TFDM dispenser and pallet from damage during shipment. The purpose of the tests was to ascertain the practicability of a rotationally molded high density linear polyethylene shipping container to provide protection during shipment and long-term storage. Two test specimens, No. 1 and No. 2 for vibration testing, and one test specimen for rough handling testing, were subjected to all tests with successful results. The procedures and results presented within this report include those performed outside the facilities of Nash-Hammond industry.

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14. KEY WORDS	LINK A		LINK B		LINK C	
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TFDM Dispenser						
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Vibration tests						

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